in the form of snow and could not be recorded by the self-registering gauge, as rain has been recorded. In most instances the accumulated hourly amounts of precipitation that fell as snow have been credited to the hours ending 7 a. m. and 7 p. m.—the regular observation hours—with the result that the means for those hours are abnormally high for the winter months. To a less extent accumulated amounts have been credited to the hour ending at midnight, which has caused a slight rise in the mean for that hour. This trouble does not appear in the records for the warm months of the year, May to September, inclusive, and is seen to but a small extent in the records for April and October.

TABLE 1.—*Average hourly precipitation at Topeka, Kans., 1905–1923*

[Inches and hundredths]

Month	A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight
January	0.02	0.01	0.02	0.03	0.02	0.03	0.13	0.02	0.02	0.01	0.02	0.03	0.02	0.01	0.02	0.03	0.02	0.04	0.12	0.03	0.03	0.03	0.04	0.08
February	0.04	0.05	0.02	0.06	0.05	0.04	0.11	0.04	0.03	0.07	0.05	0.07	0.08	0.05	0.04	0.03	0.05	0.08	0.28	0.02	0.04	0.04	0.07	0.11
March	0.08	0.09	0.06	0.07	0.06	0.04	0.19	0.05	0.03	0.05	0.05	0.06	0.04	0.09	0.10	0.08	0.10	0.09	0.19	0.10	0.09	0.12	0.21	0.25
April	0.17	0.11	0.16	0.10	0.09	0.10	0.19	0.12	0.07	0.06	0.06	0.08	0.08	0.05	0.07	0.08	0.12	0.07	0.18	0.09	0.11	0.08	0.12	0.15
May	0.15	0.22	0.25	0.16	0.24	0.27	0.22	0.20	0.12	0.13	0.19	0.13	0.11	0.24	0.15	0.14	0.16	0.13	0.18	0.21	0.26	0.24	0.13	0.15
June	0.18	0.14	0.28	0.23	0.34	0.21	0.14	0.12	0.12	0.16	0.12	0.13	0.08	0.11	0.10	0.10	0.09	0.21	0.28	0.26	0.28	0.26	0.22	0.14
July	0.32	0.30	0.32	0.20	0.16	0.33	0.18	0.09	0.08	0.05	0.05	0.01	0.05	0.10	0.13	0.16	0.18	0.24	0.13	0.08	0.17	0.22	0.21	0.21
August	0.16	0.15	0.22	0.24	0.18	0.34	0.24	0.18	0.08	0.08	0.15	0.06	0.06	0.07	0.09	0.04	0.12	0.25	0.17	0.20	0.25	0.18	0.21	0.21
September	0.30	0.26	0.21	0.21	0.34	0.27	0.28	0.26	0.22	0.14	0.10	0.12	0.08	0.05	0.23	0.13	0.08	0.15	0.11	0.10	0.16	0.41	0.22	0.18
October	0.10	0.11	0.07	0.12	0.19	0.09	0.07	0.10	0.11	0.08	0.07	0.06	0.07	0.10	0.09	0.09	0.08	0.08	0.14	0.11	0.17	0.12	0.10	0.19
November	0.10	0.07	0.08	0.10	0.07	0.04	0.10	0.04	0.02	0.07	0.08	0.03	0.06	0.06	0.09	0.06	0.12	0.13	0.13	0.07	0.06	0.08	0.09	0.12
December	0.01	0.01	0.03	0.04	0.01	0.02	0.11	0.03	0.04	0.04	0.02	0.03	0.02	0.02	0.03	0.06	0.06	0.05	0.15	0.04	0.03	0.03	0.04	0.08
Entire period	0.14	0.13	0.14	0.13	0.15	0.15	0.16	0.10	0.08	0.08	0.08	0.07	0.06	0.08	0.10	0.08	0.10	0.13	0.17	0.11	0.14	0.15	0.14	0.16
April to September, inclusive	0.21	0.19	0.24	0.19	0.22	0.25	0.21	0.16	0.12	0.10	0.11	0.09	0.08	0.10	0.13	0.11	0.12	0.18	0.18	0.16	0.20	0.23	0.18	0.18

THUNDERSTORM AT MEMPHIS, TENN., APRIL 29, 1924

By A. R. LONG, Observer

[Weather Bureau, Memphis, Tenn., May 10, 1924]

The weather map on the morning of April 29 showed an area of low pressure of considerable intensity central over Oklahoma. On the morning of April 30 it was central over the lower Ohio Valley. Numerous thunderstorms occurred on the eastern and southern sides of this low-pressure area.

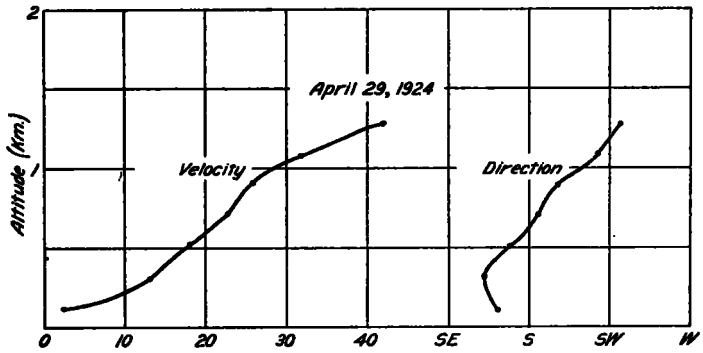

FIG. 1.—Wind velocity and direction just previous to thunderstorm (3:11 p. m.)

A thunderstorm of mild character occurred at Memphis on the morning of April 29. Another thunderstorm occurred during the afternoon, and the following notes are taken from the station records. First thunder heard at 3:20 p. m. and continued at lengthy intervals until 7 p. m. Rain began 3:50 p. m. and ended 7:20 p. m. A trace of hail fell from 4 p. m. until 4:01 p. m. Excessive precipitation began 4 p. m. and ended 4:30 p. m. A maximum wind velocity of 52 miles and an extreme velocity of 64 miles per hour from the northwest occurred at 3:57 p. m.

A peculiar feature of this storm can best be described as a large whirlwind cutting a path about 30 feet wide. It was first noticed on the Arkansas side of the river, where part of a large tree was blown down about 3:55 p. m. Moving from a WNW. direction across the river, it carried spray from the surface of the water spirally upward in a counterclockwise direction to the base of the low-lying clouds. The clouds at this point were very turbulent and moving rapidly from the WNW. In its passage across Wolf River, to the east of and parallel to the Mississippi River, it seemed to disturb the houseboats in its path more than the other houseboats on either side. Several windows were broken out of the Fall Building, situated upon the bluff about 500 feet from Wolf River and in the path of this disturbance, while adjoining buildings on both sides escaped undamaged. Branches were broken off of a number of trees and a few windows broken at several other places in the city, but no serious damage was reported.

551.574 (749)

FROST ON THE CRANBERRY BOGS OF NEW JERSEY

By GEORGE S. BLISS, Meteorologist

[Weather Bureau Office, Philadelphia, Pa., January 26, 1924]

The Weather Bureau has studied frost conditions on the cranberry bogs for many years, partly for the purpose of improving the forecasts and effecting greater savings thereby, and partly because of the interesting meteorological problems that the conditions present.

In 1906 and 1907 Prof. Henry J. Cox, of the Chicago station, made an exhaustive study of these conditions on the Wisconsin bogs, and the results were published as Bulletin T, W. B. No. 443. In 1917 Mr. C. A. Donnel spent the fall season at Whitesbog, N. J., and studied the physical conditions, but did not carry his studies far enough to work out any conclusive results.

In the fall of 1921 the Weather Bureau began a series of temperature and humidity observations at Whitesbog, under the supervision of the writer, for the purpose of obtaining data from which to compute a radiation formula (i. e., an equation from which to compute the minimum to which the radiation will carry the temperature during the night) for use in forecasting bog minimum temperatures. The fall series of observations was made

by Mr. C. C. Hamme, and the following spring series by Mr. Charles I. Dague. The results were analyzed and published in the MONTHLY WEATHER REVIEW for October, 1922.

This analysis showed that it would be necessary to have a greater number of observations before a reliable working formula could be computed. The results, however, were decidedly encouraging, for they gave assurance that a good radiation formula could be depended upon for more accurate results than had been possible by any other means yet tried. Clearly, too, such a formula could be employed by the grower to give him fairly dependable information, a desirable self-aid when he is not in touch with a Weather Bureau Office.

The application of a radiation formula requires very careful and accurate observational work in order to reduce errors to a minimum. It is advisable to take three sets of thermometer readings at each observation, and to use that set that gives the lowest dew point.

The Weather Bureau did not have funds to continue the observations at Whitesbog, and in the fall of 1922 the work was obligingly taken over by Mr. Charles S. Beckwith, special cranberry agent for the State of New Jersey. When Mr. Beckwith finished the series of observations last autumn we then had data for a total of 76 good radiation nights with the bog minima 40° or lower.

When the first analysis of the observations was made, and published in the MONTHLY WEATHER REVIEW, there were data for only 25 good radiation nights, and the writer was inclined to favor a straight-line formula that was computed by the method of least squares. A study of the larger number of observations now available has revealed the fact that such a formula is not flexible enough, or, in other words, does not have latitude enough, to cover the somewhat freakish conditions that are sometimes experienced on the bogs. The type of formula used by Mr. Floyd D. Young in California is better, because it employs variables that may be computed to fit the conditions. These observations also show that there is a decided difference between the radiation conditions of spring and of fall, hence it has been necessary to compute two sets of variables in order to cover this difference.

The formula which has been used by Mr. Young is as follows:

$$T = D - \frac{H-25}{4} + V - V'$$

in which T is the prospective bog minimum temperature; D the p. m. dewpoint; H the p. m. relative humidity; V a variable depending upon the dewpoint; and V' a variable depending upon the humidity.

The values given in Table 1 have been computed in accordance with the temperature and humidity conditions recorded on the 76 nights before mentioned, and they are no doubt very close to the results that we might expect if data were available from a much larger number of observations.

Application of the formula with the values of Table 1 to the conditions on the 76 nights before mentioned gives the results shown in Table 2.

With the most careful observational work possible, we may expect an occasional difference of as much as 3° between the actual and the computed dewpoint, and it will be noted that on 60 of the 76 nights, or approximately 80 per cent of the time, the difference between the observed and the computed minimum temperatures does not exceed that amount. Therefore the formula may be considered as about 80 per cent correct.

It is believed that this formula and the values as tabulated will apply with equal accuracy to all of the bogs in New Jersey with the possible exception of those nearest to the coast. For bogs in other latitudes, such as Cape Cod, or in Wisconsin, it would no doubt be necessary to compute a different set, or sets, of values to use in the minimum temperature equation.

TABLE 1.—*Computed values of V and V′ in the radiation equation* $(T = D - \frac{H-25}{4} + V - V')$

SPRING VALUES

Dew-point	V	Humidity	V′
°F.		Per cent	
25–27	3	25–40	0
28–30	2	41–52	—1
31	1	53–59	—2
32	0	60–66	—3
33–34	—1	67–71	—4
35–36	—2	72–76	—5
37–38	—3	77–81	—6
39–40	—4	82–86	—7
41–42	—5	87 up	—8
43–44	—6		
45–46	—7		
47–48	—8		
49–50	—9		
51–52	—10		
53–54	—11		
55	—12		
56–57	—13		
58	—14		
59–60	—15		
61	—16		
62–63	—17		
64	—18		
65–66	—19		
67	—20		
68	—21		

FALL VALUES

Dew-point	V	Humidity	V′
°F.		Per cent	
20–24	0	25–40	1
25–29	—1	41–52	0
30	—2	53–57	—1
31	—3	58–62	—2
32	—4	63–67	—3
33–34	—5	68–71	—4
35–37	—6	72–76	—5
38–40	—7	77–81	—6
41–43	—8	82–86	—7
44–46	—9	87 up	—8
47–50	—10		
51–53	—11		
54–55	—12		
56–57	—13		
58–59	—14		
60	—15		
61–62	—16		
63	—17		
64–65	—18		
66	—19		

TABLE 2.—*Comparisons of observed minimum temperatures with values forecast from computations from the radiation equation* $(T = D - \frac{H-25}{4} + V - V')$

SPRING SERIES

Date	Temperature, p. m.	Relative humidity p. m.	Dew point, p. m.	Forecast bog minimum	Actual bog minimum	Error
1922	°F.	Per cent	°F.	°F.	°F.	°F.
May 8–9	62	26	27	29.8	31.0	−1.2
10–11	67	65	54	36.0	39.5	−3.5
12–13	53	71	43	29.5	28.7	+0.8
15–16	59	78	52	34.8	33.7	+1.1
16–17	52	77	45	31.0	31.3	−0.3
19–20	63	50	44	32.8	38.5	−5.7
23–24	59	82	54	35.8	38.5	−2.7
24–25	61	60	46	33.3	35.8	−2.5
27–28	50	82	45	30.8	28.8	+2.0
28–29	55	64	42	30.3	30.3	±0.0
29–30	66	55	49	34.5	34.5	±0.0
30–31	63	78	55	35.8	37.2	−1.4
June 12–13	65	38	39	31.8	33.0	−1.1
13–14	54	81	48	32.0	39.4	−7.4
14–15	61	73	52	35.0	35.1	−0.1

TABLE 2.—*Comparisons of observed minimum temperatures with values forecast from computations from the radiation equation* $(T=D-\frac{H-25}{4}+V-V')$—Continued

SPRING SERIES—Continued

Date	Temperature, p. m.	Relative humidity p. m.	Dew point, p. m.	Forecast bog minimum	Actual bog minimum	Error
1923	°F.	Per cent	°F.	°F.	°F.	°F.
May 1- 2	63	37	36	31.0	28.0	+3.0
2- 3	59	52	41	30.3	32.2	−1.9
3- 4	60	50	41	30.8	30.2	+0.6
4- 5	69	50	50	35.8	35.2	+0.6
6- 7	62	62	48	33.8	33.0	+0.8
10-11	53	50	34	27.8	23.4	+4.4
13-14	65	56	49	34.3	32.0	+2.3
14-15	61	35	33	29.8	31.5	−1.7
22-23	68	50	49	34.8	34.5	+0.3
23-24	65	48	45	33.3	28.5	+4.8
24-25	60	34	32	29.8	30.0	−0.2
25-26	76	38	48	36.8	37.6	−0.8
26-27	80	41	54	40.0	40.3	−0.3
27-28	66	59	51	34.5	36.5	−2.0
31-June 1	62	81	56	35.0	33.1	+1.9
June 9-10	68	76	60	37.3	35.5	+1.8
10-11	75	66	63	38.8	41.1	−2.3
29-30	72	85	68	39.0	37.0	+2.0

Average error, −0.4°.

FALL SERIES

1921						
Sept. 22-23	81	79	57	36.5	42.0	−5.5
23-24	82	80	59	37.3	31.5	+5.8
24-25	76	93	52	32.0	40.0	−8.0
25-26	81	91	68	40.5	38.0	+2.5
26-27	74	92	47	28.3	29.8	−1.5
30-Oct. 1	86	92	55	34.3	29.0	+5.3
Oct. 1- 2	69	84	45	28.3	29.3	−1.0
3- 4	65	94	61	35.8	34.0	+1.8
4- 5	64	85	40	25.0	29.4	−4.4
6- 7	70	76	45	28.3	29.8	−1.5
8- 9	48	80	38	23.3	22.0	+1.3
9-10	60	87	38	23.5	29.0	−5.5
10-11	76	83	52	33.5	32.0	+1.5
12-13	56	77	37	24.0	22.0	+2.0
13-14	54	89	32	20.0	18.9	+1.1
14-15	70	96	39	22.3	21.4	+0.9
1922						
Sept. 22-23	60	72	51	33.3	36.2	−2.9
25-26	54	54	37	24.8	25.0	−0.2
26-27	52	78	45	28.8	28.1	+0.7
27-28	61	89	58	36.0	38.7	−2.7
Oct. 12-13	53	52	36	23.3	29.5	−6.2
13-14	52	62	39	24.8	27.1	−2.3
17-18	64	59	50	33.5	31.0	+2.5
18-19	50	48	30	22.3	20.0	+2.3
19-20	40	68	30	21.3	24.0	−2.7
24-25	34	81	29	20.0	22.5	−2.5
26-27	40	53	26	19.0	16.5	+2.5
1923						
Sept. 10-11	64	70	54	34.8	34.5	+0.3
11-12	64	82	58	36.8	39.5	−2.7
14-15	52	63	40	26.5	27.5	−1.0
15-16	54	73	45	29.0	29.5	−0.5
16-17	54	59	40	26.5	26.0	+0.5
17-18	55	65	43	28.0	28.0	±0.0
29-30	70	72	61	38.3	36.0	+2.3
Oct. 1- 2	56	65	44	28.0	31.0	−3.0
2- 3	61	65	49	32.0	34.0	−2.0
3- 4	56	65	44	28.0	33.0	−5.0
4- 5	65	52	47	30.3	22.5	+7.8
5- 6	45	78	38	23.8	24.0	−0.2
6- 7	44	78	37	23.8	15.5	+8.3
7- 8	45	86	41	24.8	20.3	+4.5
8- 9	47	69	37	24.0	20.0	+4.0
9-10	46	77	38	24.0	23.0	+1.0

Average error, −0.6°.

WEATHER DURING APRIL 21–26, 1924, AND THE FREE-BALLOON FLIGHTS OF APRIL 23–25

By V. E. JAKL, Meteorologist

[Weather Bureau, Washington, May 24, 1924]

The sequence of weather conditions over the country during the period of April 21–26, of more than passing interest in themselves, is of additional interest in view of the free-balloon flights of April 23–25, and their meteorological significance. An account of the national balloon race of 1924 and of the participation of the Weather Bureau in furnishing the pilots with all possible information before and during the flights, is given in the following extract from the report of Mr. J. H. Jarboe, official in charge of the Weather Bureau station at San Antonio, Tex.:

Seven balloons started from San Antonio, Tex., during the late afternoon of April 23, 1924, competing for distance in the national elimination balloon race. No records were broken, but four balloons exceeded a thousand miles, and the average mileage for the seven contestants was 798. The general course taken by all balloons was somewhat east of north, and closely coincided with the surface isobars, but the rapid and continuous movement of the balloons northward was quite unusual. Thunderstorms were encountered by all pilots as the balloons neared the center of low pressure, the first balloon being forced down 16 hours 46 minutes after the start.

Six of the balloons were equipped with radio sets, and the pilots received weather forecasts during their flight. Their logs show that messages came in from numbers of stations, some reaching as far eastward as New York the first night.

A rather comprehensive schedule for supplying meteorological information was conducted. Weather maps, forecasts, and upper-air conditions from Weather Bureau and Army aerological stations were supplied in bulletin form, and pilot-balloon runs were made hourly at the field by the Army meteorological detachment. The contestants were well informed of current and expected weather development before leaving the ground, and ample provision was made for supplying this information by radiophone during the race. Pilots were keenly interested in this feature, taking with them weather maps, forecasts, reported wind velocity aloft, and a schedule of broadcasting stations. The distance covered, time in the air, and the approximate location of the place landed are shown herewith:

Pilot	Duration			Miles	Landed (near)
	H.	M.	S.		
Van Orman	44	4	44.6	1,072	Rochester, Minn.
Honeywell	39	11	0	1,042	Sanborn, Minn.
Peek	32	27	15	1,021	St. Ansgar, Iowa.
Thaden	34	8	26.2	1,003	Dubuque, Iowa.
Hill	25	20	20	565	Moline, Kans.
Fournier	18	7	32	517	Kaw City, Okla.
McKinley	16	46	0	365	Wapanucka, Okla.

The balloons started off with a surface wind of 12 to 14 miles per hour from the southeast. They traveled at altitudes of 200 to 400 meters, but increased their altitudes during the night and were soon making 30 to 35 miles an hour. Air currents at an altitude of 500 to 1,500 meters were used for the larger part of the race, the balloons traveling so rapidly at times that the pilots experienced difficulty estimating their positions.

Weather conditions and forecasts indicated that the balloons were being drawn into the center of the LOW while crossing Kansas, and altitudes up to and above 5,000 meters were used. Snow and freezing temperatures were encountered in the higher levels, as well as physical discomfort due to altitude. On the morning of April 25 four balloons were still in the air above northern Iowa and southern Minnesota, with the center of the LOW south of them. Thunderstorms and adverse winds on this date brought the race to a close, and the victory to W. T. Van Orman.

The week opened with an elongated LOW central over Missouri, attended by precipitation over its northern portion. This LOW was displaced the following morning (22d) by a weak HIGH, the LOW meanwhile passing off northeastward with increasing area of precipitation. By the morning of the 23d, the HIGH had increased in extent and depth and was overlying practically all the eastern half of the country. Coincidently with the development of this HIGH, scattered areas of low pressure in the west later merged into a well-marked trough that covered the western half of the country by the morning of the 23d, the major axis of the trough extending about NE. to SW. over the plateau region.

This distribution of pressure on the 23d indicated general south to north movement of air over middle sections of the country, the low and high areas being separated by approximately straight isobars extending from the Gulf to Canada. Wind conditions were therefore favorable for distance flights from San Antonio, as, following the gradient winds at moderate altitudes, the